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THE STATUS OF CERTAIN OF THE MINERAL METABOLISM INDICES IN PERSONS WORKING UNDER CONDITIONS INFLUENCED BY BERYLLIUM COMPOUNDS

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[Sostoyaniye nekotorykh pokazateley mineral'nogo obmena u lyudey, rabotayushchikh v usloviyakh vozdeystviya soyedineniy berilliya]

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THE STATUS OF CERTAIN OF THE MINERAL METABOLISM INDICES IN PERSONS WORKING UNDER CONDITIONS INFLUENCED BY BERYLLIUM COMPOUNDS*

Beryllium, being a bivalent metal, enters into competitive interrelations with the ions of other bivalent metals that are natural enzyme activators (magnesium, calcium, manganese, and others), while, at the same time, depressing their activity (Klemperer et al.; I. V. Pavlova; N. M. Karamzina, and I. V. Pavlova; Aldridge, and others). This is why the study of the status of those electrolytes that can be beryllium antagonists among persons in contact with its compounds has taken on such great importance.

Earlier research on magnesium and calcium metabolism among those stricken with berylliosis and who broke off their contact with the toxic substance several years ago showed a disarrangement in the relationship between these electrolytes. Also observed was a reduction in the magnesium level in the blood (plasma and erythrocytes), together with a tendency to its increased excretion with the urine and simultaneously an increase in the calcium content in the blood serum and a decrease in its excretion. It was difficult to ascertain whether or not it was the direct influence of the beryllium deposited in the organs that was causing the changes indicated in the mineral metabolism, in the metabolism of the electrolytes, or whether this is a manifestation of pathological reactions taking place in the body in the course of berylliosis. We assumed that an investigation of the status of the mineral metabolism among persons who, for all practical purposes were healthy, but who were in constant contact with beryllium compounds, should help to shed some light on this question.

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* Institute of Industrial Hygiene and Industrial Diseases of the Academy of Medical Sciences of the USSR. (Submitted 29 April 1969).

The content of magnesium (Andreason's method), chlorides (Levinson's method), inorganic phosphorus (the method used by Fiske and Subbarow), and calcium (the method used by Clark and Collip) in the blood serum of 50 workers in the shop machining beryllium disks in an X-ray machine plant, and of 21 persons with no contact with toxic substances, was determined. Included in the selection of the mineral metabolism indices were the intrinsic values of the ions of the bivalent metals in the most important body reactions, their competitive interrelationship with each other, and their capacity to form colloidal phosphate compounds in blood plasma. Determination of the chlorides content was made because of the indication in the literature on the subject that there is a reduction in their level in the blood of those stricken with berylliosis (V. V. Ozerova).

A study of sanitation and hygienic working conditions (D. M. Bobrishehev-Pushkin) in the section machining the beryllium disks revealed that the air in the work area was polluted with soluble, as well as insoluble, beryllium compounds during all operations performed in the shop (unpacking the disks, grinding, soldering, annealing). Yet clinical and X-ray examinations failed to turn up any industrial diseases in any of the workers.

The paper we published, in which we reported the results of a determination of the beryllium in the blood of these same workers, pointed out the clear-cut relationship between the frequency of detection of the toxic substance in the blood and the degree of contact with the substance. Beryllium concentrations of from 1.75 to 5.37 μg% were found in the blood of those directly engaged in machining the metal, a process that releases beryllium. There was no beryllium in the blood of those workers who took no part in the manufacturing process. Hence, for purposes of working with the materials from

the investigation of mineral metabolism, all persons examined were distributed in two groups according to degree of contact with the toxic substance. The first group included those workers engaged in the manufacturing process of machining the metal (grinding, soldering, annealing), while the second group included those persons who did not work in the space permanently (laboratory technicians, foremen, secondary workers). Personnel in the first group then were further broken down into three subgroups according to the time they had been working in the plant as follows: (a) less than 1 year; (b) from 1 to 10 years; (c) over ten years. These workers were subjected to three dynamic examinations at six-month intervals, the first involving 31, the second 29, and the third 15 men. Those in the third examination had worked from 18 months to 17 years, most of them (11) over 10 years. The first and second examinations were used to determine the magnesium, calcium, and chlorides content in the blood serum, while the third added the concentration of magnesium and chlorides in the erythrocytes and the inorganic phosphorus in the blood serum. The data obtained were processed using the statistical method suggested by Ye. V. Montsevichyut-Eringen.

The results (see table) of the study showed that among the workers included in the first and second groups the calcium, inorganic phosphorus, and chlorides content in the blood serum (as well as of chlorides in the erythrocytes) was approximately that found among persons in the control group. Moreover, a definite behavior pattern was noted in the reduction in the magnesium level in the blood among all those examined. Observed among those working under conditions of constant production contact with beryllium, for example, was a reliable reduction in the electrolyte content, whereas there was only a tendency toward a reduction in its level in the blood among the workers in the second group. Moreover, a definite relationship between the

Content of Certain Electrolytes in the Blood of Persons Working in Contact with Beryllium (mg%)

Group examined	Time on job	Examination	No. examined	Calcium	Inorganic phosphorus	Magnesium		Chlorides	
				Serum		Serum	Erythrocytes	Serum	Erythrocytes
Control			21	9,94±0,15	2,75±0,06	2,61±0,06	6,23±0,2	610,5±6,44	246,9±9,49
1st group	less than 1 year	1st	11	9,54±0,25 P=17%		2,09±0,14 P=0,2%		602±7,8 P=49%	
	1-10 years	"	9	9,93±0,27		2,23±0,09 P=0,2%		605,8±6,8 P=62%	
		2nd	15	10,07±0,12 P=49%		2,29±0,09 P=0,3%			
	Over 10 years	1st	11	9,51±0,26 P=17%		1,83±0,16 P<0,1%		615,2±6,31 P=69%	
		2nd	14	9,95±0,12		1,94±0,15 P<0,1%			
		3rd	15	10,32±0,12 P=1%	2,57±0,07 P=6%	1,86±0,09 P<0,1%	3,89±0,299 P=3%	602,3±5,57 P=43%	271,2±14,5 P=16%
2nd group	8 months-6 years	1st	10	10,12±0,25 P=55%		2,4±0,087 P=5%		605,1±5,47 P=56%	

Commas represent decimal points.

degree of magnesium reduction in the serum and the length of time worked in the plant can be stated. Whereas the magnesium concentration in the blood serum of those working the plant for less than one year was 2.08 mg%, it was considerably lower, 1.83 mg%, in those working uder these same conditions for over 10 years during the first examination, 1.94 mg% during the second examination, and 1.86 mg% during the third examination, as against 2.61 mg% in the control group. Changes were less pronounced among personnel who had worked in the plant from 1 to 10 years than they were among those in the first two subgroups. The magnesium level in the blood serum in this subgroup was 2.23 mg% during the first, and 2.29 mg% during the second, examination. More pronounced shifts in the magnesium metabolism were recorded for long-term effects of the toxic agent (over 10 years).

The results of the studies made among persons in the first group have some similarity to the data obtained from the examination of those suffering from chronic berylliosis, with a reduction in the magnesium level in the blood (serum and erythrocytes) noted here and there. At the same time, and as distinguished from the afflicted, among whom a simultaneous increase in the content in the blood of another bivalent ion, calcium, was observed, the calcium level in the blood serum of healthy personnel working in contact with beryllium showed no deviation from the norm. The unidirectionality of the changes in the indices for magnesium content in the blood of those suffering from chronic berylliosis and among healthy persons with no signs of industrial disease but subjected to the constant activity of the toxic substance should, it would appear, be taken as the consequence of the specific action of beryllium on magnesium metabolism. We were unable to investigate content of electrolytes in the urine under production conditions, so the results contained

in this paper are such that it is impossible to determine the sort of mechanism that is at the basis of the observed phenomenon and what the chances are of magnesium being present in the body. At the same time, shedding some light on questions concerned with whether or not the reduction in the magnesium level in the blood corresponds to its insufficiency in the body, or whether there is some sort of mechanism for the redistribution of the element throughout the body when beryllium is acting, is highly important because we know that a magnesium deficit can lead to functional and morphological changes in the body.

Conclusion

Observed among personnel who are, for all practical purposes, healthy, but who work under conditions in which beryllium compounds are acting, is a reduction in the magnesium content in the blood, the level of which depends on the degree and duration of contact with the toxic substance. Other indices of mineral metabolism (calcium, inorganic phosphorus, blood chlorides) remain within the limits of normal magnitudes.

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